WIRELESS TELEPHONE COUPLER

Priority Claim

[0001] This application claims the benefit of U.S. Provisional Application No. 60/266,993 filed February 7, 2001 entitled "Cellular Telephone Coupler," the entire content of which is expressly incorporated by reference, and U.S. Provisional Application No. 60/269,046 filed February 15, 2001 entitled "Cellular Telephone Coupler," the entire content of which is expressly incorporated by reference.

Field of the Invention

[0002] This invention relates to telecommunications and more particularly to providing data access to the Internet and other networks, and to providing facsimile communication, all via wireless telephones.

Background of the Invention

[0003] Computers and facsimile machines are commonly enabled to communicate over the Public Switched Telephone Network (PSTN) through modems interfacing between them and standard 2-wire telephone lines. Situations occur wherein a telephone is available but connection to the telephone line, such as through an RJ-11 modular connector, is not, as in the case of public pay phones and telephones connected to PBX systems. In such cases acoustic coupling devices have been developed as described in Gutzmer US 5,134,649. Gutzmer in US 4,907,267 and US 5,455,859 teaches interfacing devices for connecting modems to PBX and PSTN-connected base telephone instruments through the four-wire handset connectors such as RJ-9 modular jacks.

Summary of the Invention

[0004] The preferred embodiments of the present invention provide a wireless telephone coupler enabling wireless telephones to be connected to any portable or fixed data device such as a computer having a modem. Wireless telephones include, but are not limited to, the well-known household and industrial 'cordless' phones which communicate with Radio Frequency (RF) electromagnetic waves to a single local base unit, and mobile 'cell phones' which communicate, typically at greater distances and with many users, using RF

electromagnetic waves to one or more fixed location cells in a matrix of cells making up a cellular network such as the widespread analog network "Advance Mobile Phone Service (AMPS)" serving a large number of customers and providing hand-off of calls from one cell to another as the mobile customer moves within the covered region.

[0005] A significant feature of the preferred embodiments is that the electrical connections to the wireless telephone do not ordinarily require any physical modification to the telephone unit. Rather, electrical connection to the wireless telephone is made via its "hands-free" circuitry. Many wireless telephones, including cell phones and cordless phones, have a hands-free jack such as a three-conductor triaxial 2.5 mm socket for use with headsets to allow hands-free voice communication. Some cell phones have a somewhat smaller socket and some require an adapter to their proprietary interface connectors for use with hands-free headsets. Generally such adapters are readily available at low-cost. Using this invention, the computer modem is connected via the wireless telephone to a distant modem to obtain distant data through the PSTN or other communication network. The computer is thus enabled to communicate data through the voice channel with a distant modem for Internet access using a wireless telephone without expensive special Internet Service Provider (ISP) monthly charges for data service and without special data cables unique to particular cell phones, which often require licensing agreements and associated costs.

[0006] Another significant feature of the preferred embodiments of this invention is that they do not require audio coupling transformers, thereby enabling reduced size, weight and cost.

[0007] Additional important advantages of the preferred embodiments is provision for RF shielding and/or filtering to protect against interference from RF transmissions and RF conductance from the adjoined wireless telephones, and RF emissions and conductance from the adjoined computers.

<u>Brief Description of the Drawings</u>

[0008] Figure **1** is a general block diagram of a preferred embodiment of the invention;

[0009] Figure **2** is an exploded perspective illustration of one embodiment of a wireless telephone coupler;

[0010] Figure **3** is block diagram of the functional elements of the electronics of one embodiment of the invention;

[0011] Figures **4A** and **4B** show a detailed electronic schematic diagram of one embodiment of the wireless telephone coupler;

[0012] Figure **5** is an enlarged view of illustrates a typical 2.5 mm cable plug useable with the certain preferred embodiments of the invention;

[0013] Figure **6** illustrates a schematic diagram for an inverting cable for connecting a wireless telephone coupler to a wireless telephone; and

[0014] Figure **7** is a connection table for the inverting cable of Figure **6**.

Detailed Description of the Preferred Embodiment

[0015] Referring to Figure **1,** the overall system of one preferred embodiment of the invention includes a wireless telephone coupler **10** having a two wire input connected to a modem lead **15** which includes standard telephone RJ-11 modular jacks **20** on each end. Coupler **10** has a two-signal output connecting to plug **30-A** at one end of cable **25**. The other end of cable **25** is connected to a plug **30-B**. Plug **30-B** is inserted into the standard hands-free headset socket **35**. A three-conductor triaxial 2.5 mm socket is standard in many wireless telephones. However, the preferred embodiments of the invention can be adopted for use with other "hands-free" circuitry including sockets smaller or larger than the 2.5 mm socket or with interface adapters as described above. As described below, cable **25** may advantageously be the inverting cable shown in Figure **6**.

[0016] Plug **30-B** is adapted to be inserted into the headset socket **35** of the wireless telephone handset **50** or an appropriate adapter connected thereto, not shown, for adapting handset **50** for hands-free headset use. RJ-11 modular jack **20** is adapted to be inserted into the mating RJ-11 telephone socket of a computer modem **45**. This modem may be a separate component but is oftentimes incorporated within the digital computer **40**.

[0017] Exemplary embodiments of computer **40** are portable computers such as laptop computers or hand-held computers, or larger office and home PC's and MACs, and may be other instruments such as facsimile machines, portable business and sales/service

instruments for field inventory, service call reporting, invoicing, parts downloading, service call routing, and point-of-sales reporting, etc.; and cash registers that normally tie into PSTN for inventory control, credit card verification, and the like. Rural ATM machines and other information-communicating instruments not accessing the PSTN are additional applications of the present invention, including emergency use of wireless telephones for banks, ATM machines, sales desks, and the like when the PSTN is temporarily overloaded or inoperative and the communication services are vital. All of these applications, and others that will become obvious to those in the field, may benefit from the present invention. The term computer herein is taken to cover all such instruments, communication devices, machines, and may include a modem, either internally or externally located, and connected thereto.

[0018] Continuing with Figure **1**, audio signals initiated within modem **45** and conducted to coupler **10** are termed transmit signals and flow in transmit direction **85** according to conventional terminology in the telecommunications industry. Signals coming from the distant modem, not shown, via the PSTN **80**, base station **60**, radio waves **70**, wireless handset **50**, cable **25**, coupler **10**, and lead **15** to arrive at modem **45** are traveling in receive direction **90**. As is well known, both transmit signals and receive signals are carried over the same wires or communication means of the telephone system. Transmit signals delivered to handset **50** enter the handset microphone interface at socket **35** through inverting cable 25. Such transmit signals are directed within handset **50** to a microphone amplifier, not shown. Coupler **10** is required to attenuate transmit signals in order to offset voltage gain of the microphone amplifier in order to avoid excessive signal amplitudes. Transmit and receive signals are communicated between handset **50** and telephone base station **60** through radio waves **70** generated and received between handset antenna **55** and base station antenna **65**. Such radio waves **70** are generally in the Radio Frequency (RF) range between 40 MHz and 6000 MHz. Future RF communication links for wireless telephony may be outside of this range, yet be useable with the present invention.

[0019] Base station **60** may be a cordless telephone base such as in a home or business, a cordless telephone network servicing base, a cellular telephone cell communicating with a central cellular telephone system, or other telecommunication

equipment. Base station **60** is connected to PSTN through cable **80** and may include RJ-11 modular jacks **20**.

[0020] It will be understood by those skilled in the art that the preferred embodiments described herein are believed to be useful for all analog cellular networks. However, digital cellular networks often utilize non-linear coding and compression which generally prevent useful transmission of modem signals. Additional uses of the preferred embodiments are described below.

[0021] The drawing of Figure **2** illustrates an exploded view of coupler **10** showing electronic circuit board **100** which includes RJ-11 socket **110** for connection to a modem, and a jack **36** for receiving plug **30-A**. Additional components on circuit board **100** will be described below. Housing base **125** accepts a common 9-volt battery, not shown, and battery cover **140**. Circuit board **100** is captured between lower housing **125** and upper housing **120**, and the assembly is closed with upper cover **150**.

[0022] In some applications the RF fields may be substantial and, in addition to RF filtering described below, will require extensive shielding of circuit board **100**. Conductive coatings inside the housing to create a substantially RF-tight conductive enclosures or Faraday shield, may be applied using metallic deposition techniques well known in the art. Conductive coating **130** is partially illustrated within lower housing **125**, and advantageously covers substantially all inner plastic surfaces except the top surfaces of four LED light pipes **135**. Top light pipe surfaces **137** are light input surfaces that conduct LED emissions into the plastic structure to indicate the modem off-hook occurrence, which is an important feature described below. Other housing configurations of various shapes and designs may be used while employing this invention.

[0023] Figure **3** depicts five major elements of electronics **200** of the coupler, including MODEM RF FILTERS AND INTERFACE CURRENT SOURCE **210** to reduce interference from RF fields and supply current required for modem operation via RJ-11 socket **110**. LED FLASH, TIMER, BATTERY INDICATOR, AND POWER SWITCH **220** provide an LED visual indicator that flashes momentarily upon the event of the modem making it's connection, commonly referred to going off-hook. The intensity of the LED indicator is a measure of battery charge condition. BATTERY INTERFACE AND

REFERENCE VOLTAGE SOURCE **230** provides power for the circuit and a reference voltage for biasing various elements to be discussed below. The above three major elements are described in detail in conjunction with Figure **4A** below.

[0024] The remaining two major elements in Figure 3 are described in detail in Figure 4B below. VOICE CIRCUIT **240** is a conversion circuit for connecting the audio output signal from the modem **45** to the hands-free input jack **35** of the handset **50**. HANDSET RF FILTERS AND INTERFACE **250** includes transmit signal adjustments to adapt to a variety of telephone handset microphone gain characteristics, and filters to reduce interference from RF fields. In a preferred embodiment, any RF pickup is reduced to levels sufficiently low so that the RF signals are not detected in semiconductor junctions within electronics **200**. Element **250** advantageously may include the 2.5 mm triaxial socket **36** compatible with many handset jacks or other connection to the "hands-free" circuitry as described above.

[0025] Referring to the electronic circuit diagram of Figure **4A,** connector **300** connects to a common 9-volt battery, not shown. Diode 305 protects the circuit from reverse voltage. Circuit ground **302** connects to the positive battery terminal and –Vdd **304** connects to the negative battery terminal. Divider network **310** divides and filters the supply voltage to generate a reference potential –Vref **320** buffered by voltage-follower **315** which may incorporate one of the integrated circuit operational amplifiers in a quad op-amp package MC33179DN, for example. The positive supply terminal of the amplifier package shown at voltage-follower **315** is connected to circuit ground and the negative supply terminal of the amplifier package is connected to a switched negative voltage –Vsw **325** substantially at the potential of –Vdd when a modem is connected and is off-hook.

[0026] RJ-11 socket **110** connects a modem first lead **332** to circuit ground through RF filter resistor-capacitor (RC) combination **340**. Zener diode **330** is connected across the input leads from the modem and protects the coupler electronics in the event a user incorrectly connects that input into a telephone line. RC filter **345** reduces RF interference from the modem second lead **334**. Many modems typically require a minimum dc current of approximately 8 to 20 milliamperes as would be available from a telephone line connected to the PSTN. This current is supplied to the modem from the coupler from its 9-volt battery.

Transistor Q1 **350** is a current source providing required modem off-hook holding current to maintain connection and may be one of the npn transistors in a five-transistor array such as CA3083M, or equivalent. Emitter resistors and switch **355** allow selection for high or low modem current to satisfy the specific modem requirements. Network **360** provides current source bias current and a timer function for the LED flasher. Transistor Q2 **370** biases transistor Q3 **375** following the LED timeout to act as a base-emitter voltage reference for the current source Q1 **350**. RC filter **380** insures LED driver Q4 **385** is not modulated with modem signals. Resistor 300 and the four DIAL LEDs **395** establish the LED intensity as a function of battery voltage advantageously utilizing the rapid current cutoff of the red LEDs below approximately 1.7 volts each. Thus the LED indicator rapidly produces less light intensity as battery voltage drops to about 6.8 volts, close to the lower practical limit of battery life for the circuit. Transistor Q5 **400** is driven into saturation through the bias and RC filter network **405** which also insures that modem signals do not vary the clamping action of Q5 to hold the switched supply –Vsw **325** substantially to –Vdd during the off-hook modem condition, whereas during on-hook modem conditions, that is, when the system is not in use, extremely low current is drawn from the 9-volt battery, and such battery may be left connected to the circuit for long periods of time. Audio modem signal at node **420**, which includes transmit signals and receive signals, is AC coupled through capacitor **415** to the voice circuit described below.

[0027] Figure **4B** illustrates the remainder of the coupler electronics circuit diagram. VOICE CIRCUIT **240** substantially matches the modem nodal impedance at node **420** with RC circuit **430**, and through transmit amplifier A3 **445**, provides a non-zero inverted X2 gain for transmit signals and a negative non-zero X1 gain for received signals. As a result, transmit amplifier **445** substantially nulls any receive signal passing to the output of A3 since the receive signal at receive amplifier A2 **440** output is multiplied by substantially zero gain (1-1) = 0 when RC circuit **430** matches the nodal impedance at node **420** for audio frequencies of interest, between approximately 100 Hz and approximately 4000 Hz. Any small mismatch, seen as a small echo signal, is easily eliminated by modem echo cancellers as is well known in the art. –Vref **320** through resistors **435** and **465** establishes amplifier bias values substantially midway between –Vsw and ground, minimizing any

circuit distortion and maximizing dynamic range. Receive amplifier A2 **440** provides a non-zero gain of approximately 1.5 for the signal at node **420** through input resistor **450** and feedback resistor **455**, and the voltage drop across RC circuit **430**. This gain is appropriate for wireless telephone handsets which typically include volume controls for adjusting the receive signal that is normally directed to a hands-free headset earpiece speaker, not shown. Such receive signal is, instead, directed to INTERFACE **250** at **35** on the TIP lead connected to RF filter 495 and thence to capacitor **460** for ac coupling to amplifier A2 **440**. The transmit signal from A3 is AC coupled to three attenuation resistors **470** while TRANSMIT GAIN switch **475** selects an appropriate attenuation for the instant telephone handset microphone amplifier connected thereto. The attenuation is established through voltage division of the selected resistor 470 and resistor 480 connected to -Vsw **325**, which is utilized as the common ac ground shared between the transmit and receive signals and is connected to the socket **36** shield generally representing circuit ground within wireless handsets connected thereto. RF energy induced into the shield is bypassed to circuit ground with RC filter **485**.

[0028] Figure **5** illustrates a typical 2.5 mm hands-free headset plug **30** which includes molded cover **32**, shield terminal **520**, ring terminal **510**, and tip terminal **500**.

[0029] Figure **6** is a connection diagram of a preferred inverting cable **25** which includes a plug **30** at each end, shielded conductor No. 1 **530**, shielded conductor No. 2 **540**, and connections of the inner conductors and shields to plugs **30**. Reference may be made to both Figure **6** and to Figure **7** CONNECTION TABLE for understanding the connections of inverting cable **25**. The TIP **500** contact of left plug **30-A** is electrically connected with connection **550** to center conductor **535** of shielded conductor No. 1 **530**, which on the right end at 2.5 mm plug **30-B** is connected to RING through connection **580**. In similar fashion, plug **30-A** RING **510** is connected to center conductor **545** of shielded conductor No. 2 **540** through connection **560** and is connected at the right end at plug **30-B** to the TIP terminal of plug **30-B** with connection **570**. Both shields at both ends are connected to the respective plug shields **520** with shield connections **590**.

[0030] This inverting cable **25** is for use with couplers connecting the transmit signal to the RING terminal of socket **35** as shown in Figure **4B**. The convention for wireless hands-free headsets places the earpiece speaker handset output on the RING

terminal at the handset socket, and the microphone handset input on the TIP terminal at the handset socket. If a hands-free headset, not shown, is plugged into the coupler socket **35** while connected to a modem and computer, modem tones may be heard in the hands-free headset, aiding a user while troubleshooting to confirm operation of the computer, modem, and coupler in the transmit direction. In this way a simple test mode of operation is provided.

[0031] The coupler to handset cable **25** may alternatively be non-inverting, not shown, as an alternate embodiment of this invention, in which case the coupler transmit output of RC filter **490** in Figure **4B** connects to the TIP terminal of socket **36** and the receive input at RC filter **495** connects to the RING terminal of socket **36**. This combination, however, does not facilitate the convenient test mode described above.

[0032] Other embodiments, not illustrated, include the incorporation the wireless telephone coupler within the housing of a wireless telephone, eliminating cable **25** and two sockets **35** and **36**, and providing the wireless telephone with an RJ-11 connector adapted for connection to a modem.

[0033] Although preferred processing circuitry has been described, other data processing circuits may advantageously be connected to the handset circuitry commonly provided by wireless telephones to pass data to and/or from such wireless telephones for data communications between computers and are also within the scope of this invention. Thus, while the invention has been described herein with reference to certain preferred embodiments, these embodiments have been presented by way of example only, and not to limit the scope of the invention. Accordingly, other embodiments and changes in form and detail may be made therein by one skilled in the art without departing from the spirit and scope of the invention, including embodiments which do not provide all of the benefits and features set forth herein.